INDOOR AIR QUALITY ASSESSMENT

Lincoln Elementary School
732 Chestnut Street
Springfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of building occupants, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Lincoln Elementary School (LES), 732 Chestnut Street, Springfield, Massachusetts. The request was prompted by reports of exacerbation of asthma that occupants believe to be related to environmental building conditions, primarily in classroom 4.

On June 12, 2003, a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Judy Dean of the American Lung Association and Johnny Kyles, Head Custodian, accompanied Mr. Holmes during the assessment.

The school is a two-story brick building constructed in 1910. The school contains general classrooms, computer room, gymnasium, kitchen/cafeteria, library, health suite, an occupied basement and main offices. The rubber membrane roof was reportedly replaced in 2001. Original, single-paned sash windows are openable throughout the school. Building occupants reported difficulties in opening many of the windows.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The LES houses a student population of approximately 441 in grades K-5 and a staff of approximately 50. Tests were taken during normal operations at the school, and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million of air (ppm) in twenty-two of twenty-four areas surveyed, indicating adequate ventilation in most areas of the school at the time of assessment. It is important to note, however, that a number of classrooms had opened windows and exterior doors. These conditions can greatly reduce carbon dioxide levels in classrooms.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 1) and return air through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. The majority of univents had been deactivated during the assessment. The univent in classroom 14 was activated, however, it was not operating as designed, indicating a mechanical problem. Obstructions to airflow, such as papers and books stored on univents and items in front of univent returns were seen in a number of classrooms (Pictures 2 and 3). In order for univents to provide fresh air as designed, they must remain “on” and allowed to operate while rooms are occupied. Intakes must also remain free of obstructions.

Exhaust ventilation in classrooms consists of wall-mounted grilles (Picture 4), powered by rooftop motors (Picture 5). The exhaust system was not functioning in the majority of areas surveyed, indicating that motors were deactivated or non-functional. BEHA staff examined exhaust motors on the roof and found four of five motors not operating. As with the univents, exhaust vents must be activated during occupancy. Without supply and exhaust ventilation, environmental pollutants can build up and lead to indoor air quality/comfort complaints.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that a room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is

5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix I.

Temperature readings ranged from 76 ^{o} F to 79 ^{o} F, which were very close to the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. However, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g. univents deactivated/obstructed, exhaust vents not operating).

Relative humidity measurements ranged from 57 to 70 percent, which were above the BEHA comfort range in some areas. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. On the day of the assessment, outdoor relative humidity was measured at 69 percent. With windows and exterior doors open, indoor relative humidity levels would be expected to be similar to those outside. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Damaged wooden windowsills were seen in several areas (Picture 6). A damaged wooden exterior door was observed outside of classroom 21. Damaged windowsills and/or exterior doors can allow for water penetration into the building, leading to water damage and subsequent microbial growth.

Missing/damaged mortar around brick and an open utility hole were observed on the exterior of the building (Pictures 7 and 8). Breaches in the building envelope can provide a means for moisture penetration into the building. Repeated water damage to porous building materials can result in microbial growth. The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24-48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur.

A number of areas had water-damaged ceiling and wall plaster, which can indicate leaks from the roof or plumbing system (Picture 9). No active roof leaks were reported or observed. In some areas, water damage appeared as a result of historic leaks. Occupants reported periodic plumbing leaks due to clogged drains in science room 6.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified. A number of univents had accumulated dirt, dust and debris within the air handling chambers. These conditions can be attributed to non-continual univent use, which may allow airborne particulates to settle within the units. In order to avoid distribution of particulates via the univent, the air handling sections of univents should be regularly cleaned (e.g. during regular filter changes). A number of exhaust vents in classrooms and restrooms also had accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles. Dust can be irritating to eyes, nose and respiratory tract.

Univent filters were checked and found occluded with dust and debris (Picture 10). A debris-saturated filter can obstruct airflow, damage air handling equipment and serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas via the ventilation system.

Exposed fiberglass pipe insulation was noted in classrooms 4 and 5. Airborne fiberglass particles can serve as a skin and respiratory irritants to sensitive individuals. Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks (Picture 11). The large number of items stored in classrooms provides a source for dusts to accumulate and make it difficult for custodial staff to clean. As previously mentioned, dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Cleaning products were found on countertops and beneath sinks in a number of classrooms. Cleaning products contain chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

Accumulated chalk dust and dry erase board particulate were noted in several classrooms (Picture 12). Chalk dust and dry erase board particulates can be easily aerosolized and serve as eye and respiratory irritants. In addition, materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs) (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Lastly, open utility holes were found around pipes several rooms (Picture 13). Open utility holes can provide a pathway for the movement of drafts, dusts and particulate matter between rooms and floors.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made:

1. Examine each univent to ensure proper function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
2. Change filters for air-handling equipment as per the manufacturer's instructions or more frequently if needed. Clean out interiors of univents during each filter change.
3. Clean accumulated dust on exhaust/return vents.
4. Restore exhaust ventilation in classrooms and restrooms to working order. Examine rooftop exhaust motors for proper function; repair and replace parts as needed.
5. To maximize air exchange, operate both supply and exhaust ventilation continuously during periods of school occupancy.
6. Remove all blockages from univents to ensure adequate airflow.
7. Consider having the systems re-balanced every five years by an HVAC engineering firm.
8. Repair/replace windows that are difficult to open.

9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

10. Replace/repair any water-damaged ceiling/wall plaster and building materials. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as necessary.

11. Consider repointing exterior brick.

12. Seal around utility holes on exterior of building and in classrooms with a foam insulation material.

13. Repair/replace damaged wooden windowsills and exterior doors to prevent water penetration and drafts.

14. Contact a licensed plumber to investigate and repair clogged drain in science room 6.

15. Store cleaning products properly and out of reach of students.

16. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

17. Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.

18. Rewrap or replace damaged fiberglass insulation in classrooms 4 and 5.

19. Consider adopting the US EPA document, "Tools for Schools", in order to provide self assessment and maintain a good indoor air quality environment on your building. The document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
20. See the resource manual and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These references are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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Picture 1

Univent Fresh Air Intake

Picture 2

Classroom Items on and around Univent Obstructing Airflow

Picture 3

Classroom Furniture Configured around Univent Obstructing Airflow

Picture 4

Wall-Mounted Exhaust Grill

Picture 5

Rooftop Exhaust Motor

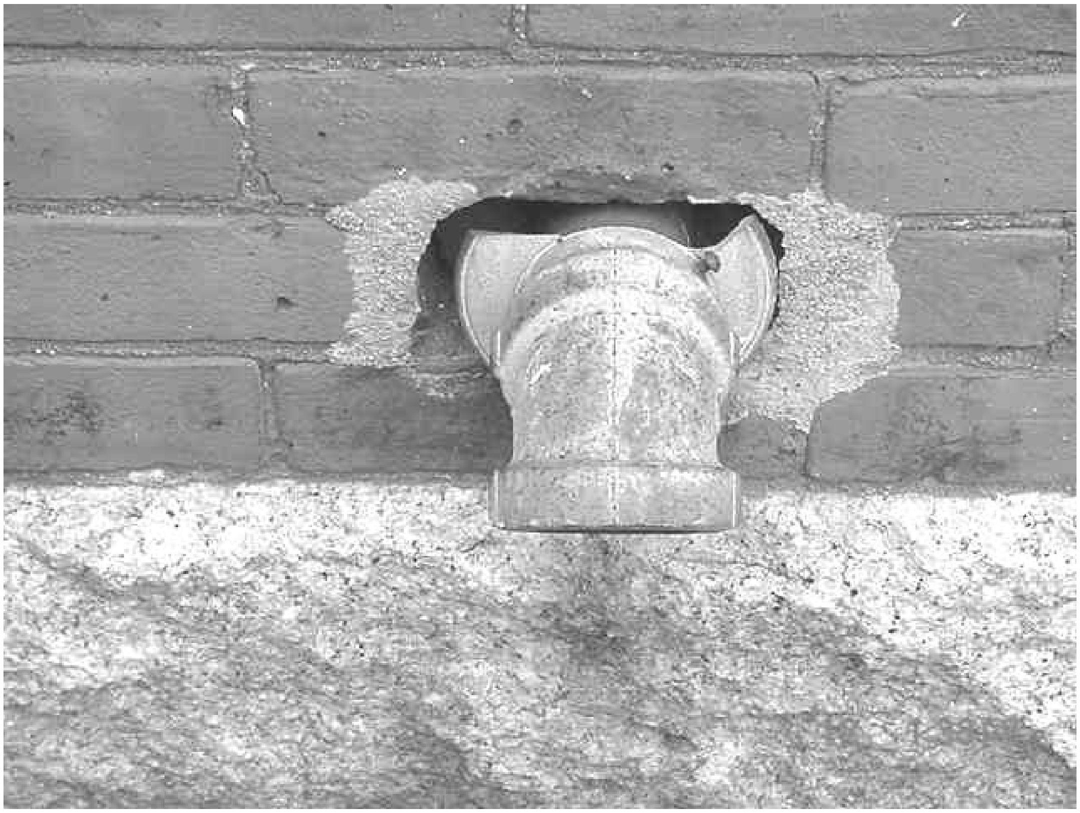
Picture 6

Damaged Wooden Windowsill

Picture 7

Missing/Damaged Mortar

Picture 8

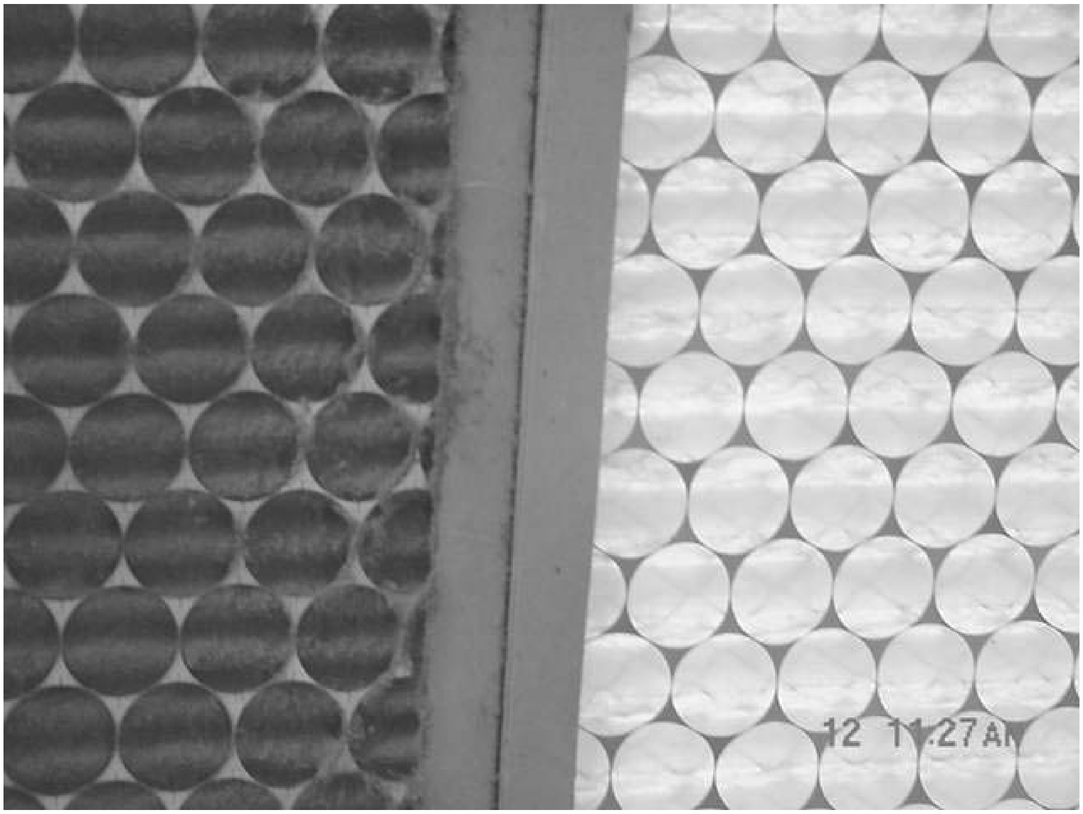


Open Utility Hole around Pipe

Picture 9

Water Damaged Ceiling/Wall Plaster

Picture 10



Dirty Filter from Univent in Classroom 4 Next to Clean Filter

Picture 11

Accumulated Items in Classroom

Picture 12

Accumulated Chalk Dust in Classroom

Picture 13

Open Utility Hole around Pipe

TABLE 1

Indoor Air Test Results – Lincoln Elementary School, Springfield, MA **June 12, 2003**

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Background	411	75	69					Warm, overcast
Room 4	700	77	64	9	Y	Y	Y	Difficulty with window, open classroom door, exhasut vents near door, pleated UV – fibers, saturated dirt, dust, debris, accumulated items, spray paint, damaged fiberglass, dry erase board, spray cleaner with bleach, items in front and on UV, pencil shavings on table top vent, computers, chalk dust dirt, dust accumulation,
Roof Top								Exhaust motor off, rec bird screen on old/open vent
Teacher's Room	566	78	61	0	Y	N	N	WD ceiling
Reading Room Lab	484	79	59	0	Y	Y	Y	WD ceiling, lamination machine, reconfigured room to facilitate air flow, UV off

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Room 14	664	78	62	15	Y	Y	Y	WD wall/ceiling plaster vent blocked with shelf, UV off, UV is on high – not operating
Room 13	867	79	61	13	Y	Y	Y	UV off, spray cleaner
Room 10	507	79	59	0	Y	Y	Y	UV off – obstructed on top and front, cleaning product on countertop
Room 11	514	79	58	10	Y	Y	Y	Window open, chalk dust, items on UV
Computer Room	445	79	57	0	Y	Y	Y	Window open, 25 computers, no AC, UV off
Room 17	837	79	60	27	Y	Y	Y	Window open, chalk dust, items on front, WD ceiling/wall plaster, plants, spray cleaner on floor
Room 8	606	78	59	14	Y	Y	Y	Window open, items on UV front
Room 76	605	78	60	2	Y	Y	Y	Short circulating
Room 3	534	78	60	4	Y	Y	Y	Window open, historic leak, stuffed animals

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Room 7	523	78	62	19	Y	Y	Y	Window open, 3 computer
Nurses Office	543	78	61	2	Y	N	N	
Room 2	582	78	62	16	Y	Y	Y	Window open
Room 6	676	77	63	16	Y	Y	Y	Window open, UV obstructed in front/on, pipe leaks, class in science room (periodic)
Room 16	514	78	62	0	Y	Y	Y	Window open, chalk dust
Room 5	771	78	64	22	Y	Y	Y	Window open, damaged fiberglass pipe insulation
Room 1	756	78	65	17	Y	Y	Y	Window open, UV blocked by furniture, items on UV
Hallway								Floor vents dirty/dusty
Basement Girl's Room								UV not open (work order)
Room 18	620	77	64	0	Y	Y	Y	Window open, carpeted, utility hole in wall, vent off

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Basement Hallway								Gas-powered leaf blower
Room 19	673	76	67	14	Y	Y	Y	Window open, UV off
Gym Office	626	76	67	2	Y	N	N	Window open
Room 21	1031	76	70	25	Y	Y	Y	Window open, chalk dust, retrofitted exhaust vent, heat complaints, exhasut/supply off
Basement Boys Room							Y	Damaged exhaust vents (on work order)
Main Office	633	78	70	1	Y	N	N	Window open, photocopier
Perimeter								Damaged wooden exhaust door outside 21, damaged grating air in – outside Room 19, missing/damaged motor, brick holes in building envelop

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